

More on the Energy/Non-Energy Commodity Price Link

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Abstract

This paper examines the energy/non-energy commodity price link, based on a reduced form econometric model and using annual data from 1960 to 2008. The transmission elasticity from energy to the non-energy index is estimated at 0.28. At a more disaggregated level, the fertilizer index exhibited the largest elasticity (0.55), followed by precious metals (0.46), food (0.27), metals and minerals (0.25), and raw materials (0.11). By

contrast, only a few price indices responded strongly to inflation, although the trend parameter estimate (often viewed as a proxy for technological progress) is negative for agriculture and positive for metals. A key implication of the pass-through results is that for as long as energy prices remain elevated, most non-energy commodity prices are expected to be high.

This paper—a product of the Global Trends Team, Development Prospects Group—is part of a larger effort in the department to analyze and understand the key determinants of commodity price movements. Policy Research Working Papers are also posted on the Web at <http://econ.worldbank.org>. The author may be contacted at jbaffes@worldbank.org.

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I. Introduction

By most accounts, the recent commodity boom was the longest and broadest (in terms of commodities involved) of the post-WWII period (World Bank 2009). Between 2003 and 2008, nominal energy and metal prices increased by 230%, food and precious metals doubled, while fertilizer prices increased four-fold. Although prices (except precious metals) have declined sharply since their mid-2008 peak, as of mid-2009 they are still considerably higher than their lows reached in early 2000s.

The breadth of the recent boom is generating renewed interest on the nature and degree of commodity price links. This paper focuses on one such link: the price transmission from energy to non-energy commodities. Specifically, 11 non-energy commodity price indices are regressed on an energy price index, a measure of inflation, and a time trend (considered as a proxy to technological change) and the corresponding estimates of transmission elasticities are derived. The paper expands earlier work (Baffes 2007) by first broadening the definition of energy (i.e., use of an energy index which includes natural gas and coal in addition to crude oil) and second extending the sample to 2008. The rest of the paper begins with a brief review of the literature on price comovement. It is then followed by a discussion of the methodology and description of the data. The results are discussed next while the last section concludes.

II. Literature review and modeling framework

Although the literature on the energy/non-energy commodity price links is relatively thin, the broader subject of price comovement has been examined extensively and in various contexts with the research falling largely within two strands. The first strand examines comovement among prices of the same commodity in different locations within the market efficiency context, also known as spatial market integration or law of one price (see Fackler and Goodwin (2001) for a literature review). A more important but

less researched subject within that strand has been the comovement between world and domestic commodity prices. This relationship includes the policy dimension by analyzing whether world price signals have been fully transmitted to domestic markets or such signals have been subjected to policy distortions (see, for example, Baffes and Gardner (2003) and Mundlak and Larson (1992)).¹

The second strand of literature examines price comovement (or lack thereof) of different commodities. It goes back to Granger (1986, p. 218) who wrote: "If x_t and y_t are a pair of prices from a jointly efficient, speculative market, they cannot be cointegrated ... if the two prices were cointegrated, one can be used to help forecast the other and this would contradict the efficient market assumption. Thus, for example, gold and silver prices, if generated by an efficient market, cannot move closely together in the long run." Granger's assertion led to research in commodity markets (e.g., MacDonald and Taylor 1988) and other markets as well, notably exchange rates (see, among others, Baillie and Bollerslev (1989) and Hakkio and Rush (1989)). This research was later questioned on several grounds including the fact that comovement reflects response to common fundamentals rather than market inefficiencies. See, for example, Agbeyebe (1992), Baffes (1993), Dwyer and Wallace (1992), and Sephton and Larsen (1991).

A similarly controversial subject has been the so-called 'excess comovement' hypothesis first discussed by Pindyck and Rotemberg (1990) who, after analyzing price movements of seven seemingly unrelated commodities (cocoa, copper, cotton, crude oil, gold, lumber, and wheat), they concluded that these prices comoved in excess of what the macroeconomic variables could explain. A number of likely explanations were given for such comovement including incomplete model, endogeneity of the macroeconomic variables, rejection of normality assumption, and bubbles or market psychology.² Subsequent research, however, challenged the excess comovement hypothesis on data and methodological grounds (see Ai, Chatrath, and Song (2006), Cashin, McDermott,

and Scott (1999), Deb, Trivedi, and Varangis (1996), and Leybourne, Lloyd, and Reed (1994)).³

The present paper examines the price transmission from energy to non-energy commodities. Specifically, it estimates transmission elasticities for 11 non-energy price indices based on the following specification:

$$\log(NON_ENERGY_t) = \mu + \beta_1 \log(ENERGY_t) + \beta_2 \log(MUV_t) + \beta_3 TIME + \varepsilon_t,$$

where NON_ENERGY_t denotes the various non-energy US dollar-based commodity price indices at time t , $ENERGY_t$ denotes the energy price index, MUV_t denotes the deflator, $TIME$ is time trend, and ε_t denotes the error term, the properties of which will be subject to empirical investigation; μ , β_1 , β_2 , and β_3 denote parameters to be estimated. Because the model is expressed in logarithms, the parameter estimates can be interpreted as elasticities.

Although the signs and magnitudes of the coefficients are not dictated by economic theory, β_1 and β_2 are expected to be positive because energy as well as other goods and services (as reflected by the measure of inflation) constitute key inputs to the production process of all commodities.⁴ (See Baffes (2007), FAO (2002), and World Bank (2009) on the various transmission channels between energy and non-energy markets; Kilian (2008) on the effects of energy shocks to the broader economy; and Schmidhuber (2006) on the impact of biofuels on agricultural markets.) On the other hand, β_3 is expected to be negative, at least for agriculture—consistent with the long term impact of technological progress on production costs as well as the low income elasticity of most food commodities, especially cereals.

As an alternative to the above specification, one could deflate both indices by dividing NON_ENERGY_t and $ENERGY_t$ with MUV_t , effectively restricting the sum of the energy index and inflation coefficients to unity (i.e., $\beta_1 + \beta_2 = 1$). Estimating nominal indices, however, relaxes the homogeneity restriction so that a direct estimate of the im-

pact of inflation can be obtained (Houthakker 1975).

Annual data for 11 non-energy indices covering the period from 1960 to 2008 are used in the analysis, giving a total of 49 observations. The Manufacture Unit Value (MUV) is used as an inflation proxy. The MUV, often considered as a developed country deflator indicator, represents the unit value index in dollar terms of manufactures exported from industrial countries weighted proportionally to the countries' exports to the developing countries.

Data on all indices are collected and reported by the World Bank (World Bank, various issues) and are defined as follows. **Energy** [world trade-based weights in square brackets] consists of crude oil [84.6%], natural gas [10.8%], and coal [4.6%]. **Non-energy** consists of metals [31.6%], fertilizers [3.6%], and agriculture [64.8%]. **Agriculture** consists of beverages [8.4%], raw materials [16.5%], and food [39.9%] while **Food** consists of cereals [11.3%], edible oils [16.3%], and other food [12.3%]. The commodity-composition of the sub-indices is as follows: **Beverages**: cocoa, coffee (arabica and robusta), tea; **Cereals**: maize, rice, sorghum, wheat; **Edible oils**: coconut oil, groundnut oil, palm oil, soybean meal, soybean oil, soybeans; **Other food**: bananas, meat (beef and chicken), oranges, shrimp, sugar; **Raw materials**: cotton, rubber, timber (logs and sawnwood); **Fertilizers**: DAP, phosphate rock, potassium chloride, TSP, urea; **Metals**: aluminum, copper, iron ore, lead, nickel, tin, zinc. Finally, a **Precious metal** index was included in the analysis—not part of the non-energy index—consisting of gold [89.7%] and silver [10.3%].

The use of low frequency data was motivated by the desire to circumvent the noise typically embedded in high frequency data and also compare the effect of energy prices on the prices of all primary commodity groups. Because most agricultural commodities are subject to crop cycles, annual frequency is, perhaps, more relevant. For example, the decision of how much land to allocate to each commodity and how much in-

puts to use is taken once a year, typically prior to planting. On the other hand, although a higher frequency would add more observations, the high variability characterizing commodity prices implies that even annual observations contain a large amount of information (Campos and Ericsson 1999).

III. Results

First, I examined the stationarity properties of all the series in log-level form using the augmented Dickey-Fuller (ADF) testing procedure (these statistics are not reported here). With the exception of the cereals index (ADF = -1.76, significant at 10%), the remaining ADF statistics ranged from -0.15 (metals) to -1.53 (other food). Appending a time trend to the ADF regressions did not alter the statistics in any significant way thus confirming the existence of a unit root. In other words, nominal commodity price indices do not exhibit a strong mean-reverting process nor they move around a linear trend; instead they are characterized by a long memory process. Differencing the series once, however, induced stationarity in all cases, implying that validating the model would require examination of the stationarity properties of its error term, in addition to conventional indicators such as R^2 s and t -ratios. Recall that non-stationarity of price series is not a surprising result considering the long period along with the low frequency of the data as well as the fact that the series were expressed in nominal terms.

Results from OLS regressions are presented in table 1. Specifically, the first four columns report parameter estimates of the constant term, energy, inflation, and the time trend, followed by the adjusted- R^2 and the ADF statistic. The estimates—reflected in the sign of the energy price coefficient as well as the conventional and stationarity statistics—indicate that energy prices and to a lesser extent inflation and technological change explain a considerable part of commodity price variability (the adjusted R^2 of all regressions averaged 0.85). Moreover, the ADF statistics were in all but one case (edible oils) far below -3.00 (they averaged -3.77), fully consistent with a stationary error term.

The parameter estimate of the non-energy index (top row of table 1) is 0.28, implying that a 10% increase in energy prices is associated with a 2.8% increase in non-energy commodity prices, in the long run. Three earlier studies—Gilbert (1989), Borenztein and Reinhart (1994), and Baffes (2007)—reported elasticities of 0.12, 0.11, and 0.16, respectively (see table 2). When the sample of the current analysis is adjusted to match the samples of these studies, the pass-through coefficient becomes remarkably similar (0.13 and 0.12, and 0.18, respectively).

The transmission elasticity of the non-energy index, however, masks some variations. The highest elasticity among the sub-indices was in fertilizer, estimated at 0.55, not surprisingly since nitrogen-based fertilizers are made directly from natural gas. Fertilizer and energy price increases during the recent boom were in line with the ones experienced during the first oil shock: from 1973 to 1974 phosphate rock and urea prices increased four-fold and three-fold in nominal terms, remarkably similar to the crude oil nominal price increase during that period, from \$2.81/barrel to \$10.97/barrel.

The transmission elasticity for agriculture, estimated at 0.27, reflects an average of wide ranging parameter estimates: beverages (0.38), food (0.27) and raw materials (0.11). The elasticity estimates of the food price index components, however, fall within a very narrow range: cereals (0.28), edible oils (0.29), and other food (0.22), all significantly different from zero at the 1% level.⁵ The metals elasticity was estimated at 0.25; yet its components presented considerable variation (individual commodity elasticity estimates are not reported here). Note that highly diverse estimates in the pass-through elasticities of metal prices were the key findings of Baffes (1997, 2007) and Chaudhri (2001).

The precious metals elasticity was estimated at 0.46—the second largest among the 11 sub-indices studied here. Its large value reflects the association of high energy prices with inflationary pressures, slower economic growth, and resource scarcity, all of

which prompt households and investors to view precious metals (especially gold) as safe investment alternatives, therefore increasing their demand and hence their prices. Not surprisingly, the two post-Bretton Woods peaks of gold prices, \$750/toz in 1980 and \$687/toz in 2008, correspond to the two crude oil price peaks, \$45/barrel and \$76/barrel, respectively (all prices are expressed in 2000 real US dollars).

Three important conclusions emerge from the analysis. First, the results show that the prices of most commodities, and especially those of fertilizers and precious metals, respond firmly to energy prices. Furthermore, such response appears to be strengthening in periods of high commodity prices as confirmed by the fact that the values of the estimated elasticities increase considerably when the recent boom is included in the analysis (in some cases the elasticities double; see difference between the last two columns of table 2). The implication is that, for as long as energy prices remain elevated, analysis of non-energy commodity markets requires understanding of the energy markets as well. On the other hand, the non-energy elasticity is insensitive to the model structure and frequency of the data as can be inferred by its remarkable similarity with the earlier studies (when adjusted for sample size).

Second, while the transmission elasticities were broadly similar, this was not the case with the inflation coefficient, β_2 , the estimates of which varied considerably in terms of sign, magnitude, and level of significance. It was positive and significantly different from zero only for precious metals and agriculture (including two of its sub-indices) while it was effectively zero for metals and fertilizers. All this implies that the relationship between inflation (at least as measured by the MUV) and nominal commodity prices is much more complex and, perhaps, changing over time. This may not be surprising if one considers that during 1972-80 (a period which includes both oil shocks) the MUV increased by 45% while during 2000-08, it increased by half as much. The nominal non-energy price index increase during these two 8-year periods was iden-

tical at 170%.

Third, the trend parameter estimates, β , are spread over an even wider range compared to energy pass-through and inflation parameter estimates. The non-energy price index, for example, shows no trend at all. Yet, the metal price index exhibited an almost 2% positive annual trend while the agriculture index showed a 1% negative annual trend. Furthermore, the trend parameter estimates of the agriculture sub-indices vary considerably both in magnitude and level of significance, from 0.08 (t -value = 0.19) for raw materials to -3.12 (t -value = 5.22) for beverages, a result consistent with Deaton's (1999, p. 27) observation that what commodity prices lack in trend, they make up in variability. On the other hand, the large variation among the trend parameter estimates implies that the validity of the Prebisch-Singer hypothesis, often discussed in the context of the secular decline of primary commodity prices, may require some rethinking (see Spraos 1980, among others).

IV. Concluding remarks

Based on 1960-2008 annual data and a simple econometric model, I estimated long-run energy transmission elasticities for 11 non-energy commodity groups. The elasticity for the non-energy index was estimated at 0.28. At a disaggregated level, the fertilizer index exhibited the largest elasticity, followed by precious metals, food, and metals & minerals.

The key implication of these findings is that, for as long as energy prices remain elevated, most non-energy commodity prices are expected to remain high and thus any analysis of non-energy commodity markets cannot be undertaken in isolation to developments in energy markets.

On the methodological side, the fact that the estimates of the current study (which included the recent commodity boom) are larger than earlier ones (not accounting for the recent boom) implies that, perhaps, time-varying parameter or switching-

regime models may be more appropriate in analyzing the energy/non-energy commodity price links. Such models could shed more light on the relationship between inflation and commodity prices; they may also enhance our understanding on the (well-researched but not yet settled) subject of the secular decline of primary commodity prices. Another avenue to pursue is, naturally, the use of higher frequency data within an error-correction framework.

ENDNOTES

- ¹ The thinly researched subject of world/domestic price comovement reflects, perhaps, the unavailability of data. That, however, changed recently for agricultural products following the research project led by Kym Anderson whose methodology (Anderson et al. 2008) resulted in a consistent global database which includes prices received by farmers and paid by consumers in 75 countries (www.worldbank.org/agdistortions).
- ² The rejection of the efficient market hypothesis in the presence of comovement argued by Granger (1986) corresponds to Pindyck and Rotemberg's (1990) 'bubbles' or 'market psychology' explanation for excess comovement—provided that prices used in Granger's sense have been adjusted accordingly by the fundamentals.
- ³ The early methodological setbacks of the literature of price comovement among different commodities may explain why the subject has not been researched more thoroughly.
- ⁴ The exogeneity of energy prices assumed here reflects the large size of energy markets compared to the size of other commodity markets as well as the fact that energy is a key input in the production process of most commodities. Hence, β_1 is interpreted as transmission elasticity rather than just a cointegration parameter, similar to the cases of domestic/world price links where domestic prices are typically assumed to be a function of world prices.
- ⁵ Commodity-specific regressions show that the high elasticity estimate of beverages is driven by cocoa ($\beta_1 = 0.52$, $t\text{-value} = 5.35$), a result with no obvious explanation. On the other hand, the similar elasticity size among food sub-indices extends to most individual commodities especially for the components of grain and edible oil indices.

TABLE 1: PARAMETER ESTIMATES

<i>INDEX</i>	μ	β_1	β_2	$100^*\beta_3$	<i>Adj-R</i> ²	<i>ADF</i>
Non-Energy	3.03@ (6.54)	0.28@ (5.24)	0.12 (0.68)	-0.01 (0.02)	0.90	-3.35**
<i>Metals</i>	3.77@ (4.80)	0.25@ (3.14)	-0.17 (0.60)	1.93@ (2.31)	0.82	-3.30**
<i>Fertilizers</i>	3.58@ (4.12)	0.55@ (4.79)	-0.30 (0.95)	0.39 (0.48)	0.81	-3.97***
<i>Agriculture</i>	2.51@ (6.90)	0.26@ (5.54)	0.33@ (2.43)	-0.99@ (2.73)	0.90	-3.81***
<i>Beverages</i>	1.83@ (3.10)	0.38@ (4.87)	0.55@ (2.63)	-3.12@ (5.22)	0.76	-4.95***
<i>Raw materials</i>	1.85@ (4.16)	0.11@ (2.15)	0.51@ (3.15)	0.08 (0.19)	0.91	-3.15**
<i>Food</i>	2.91@ (7.11)	0.27@ (4.93)	0.21 (1.39)	-0.71 (1.80)	0.85	-3.85***
Cereals	3.13@ (5.94)	0.28@ (4.23)	0.17 (0.89)	-0.87 (1.76)	0.78	-3.83***
Edible oils	3.33@ (6.16)	0.29@ (4.51)	0.12 (0.58)	-0.80 (1.50)	0.80	-2.82*
Other food	1.86@ (6.28)	0.22@ (3.81)	0.45@ (4.44)	-0.42 (1.18)	0.89	-3.60***
Precious metals	-1.40@ (3.58)	0.46@ (9.40)	1.05@ (7.61)	-1.75@ (3.68)	0.98	-3.91***

Notes: The @ sign denotes parameter estimate significant at the 5% level while the numbers in parentheses are absolute *t-values* (the corresponding variances have been estimated using White's method for heteroskedasticity-consistent standard errors.) ADF denote the MacKinnon one-sided *p-values* based on the Augmented Dickey-Fuller equation (Dickey and Fuller 1979). One (*), two (**), and three (***) asterisks indicate rejection of the existence of one unit root at the 10%, 5%, and 1% levels of significance (the respective *t-statistics* are -2.60, -2.93, and -3.58). The lag length of the ADF equations was determined by minimizing the Schwarz-loss function.

Source: Author's estimates.

TABLE 2: COMPARING LONG-RUN TRANSMISSION ELASTICITIES

	<i>Holtham (1988)</i> 1967:S1-1984:S2	<i>Gilbert (1989)</i> 1965:Q1-1986:Q2	<i>Borensztein & Reinhart (1994)</i> 1970:Q1-1992:Q3	<i>Baffes (2007)</i> 1960-2005	<i>This Study</i> 1960-2008
<i>Non-energy</i>	—	0.12	0.11	0.16	0.28
<i>Food</i>	—	0.25	—	0.18	0.27
<i>Raw materials</i>	0.08	—	—	0.04	0.11
<i>Metals</i>	0.17	0.11	—	0.11	0.25

Notes: Holtham uses semiannual data, Gilbert and Borensztein & Reinhart quarterly, and Baffes along with the present study annual. Gilbert's elasticities denote averages based of four specifications. Holtham's raw materials elasticity is an average of two elasticities based on two sets of weights. '—' indicates that the estimate is not available.

Source: Holtham (1988), Gilbert (1989), Borensztein and Reinhart (1994), Baffes (2007), and author's estimates.

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